Blockley Station Quarry, Gloucestershire

[SP 180 370]

M.J. Simms

Introduction

Blockley Station Quarry is a large, currently active, brickpit, located on the western side of the main Oxford–Birmingham railway line 4 km to the NNW of Moreton-in-Marsh (Figure 4.1) and (Figure 4.7). The quarry is an outstanding site, exposing a mudstone-dominated succession in virtually horizontal strata (Figure 4.8), comprising part of the Charmouth Mudstone Formation and representing the best-developed Luridum Sub-zone succession in the Lower Pliensbachian Substage of Britain.

Unlike most occurrences of this interval, which are condensed, incomplete or poorly known, the section at Blockley Station Quarry is thick, abundantly fossiliferous and well documented. The rich ammonite fauna has been of considerable significance in the development of ideas concerning sexual dimorphism and evolution, and will continue to be invaluable in refining the biostratigraphy of this interval.

The quarry was opened in 1925 and first recorded by Richardson in 1929. It was described briefly by Channon (1950), who was the first to appreciate the richness of the fauna. It was cited by Dean *et al.* (1961) as exposing a good section through the Luridum Subzone. Callomon (in Hallam, 1968a; in Hemingway *et al.,* 1969) gave a more detailed description of the lithological succession and sequence of ammonites, together with an updated list of bivalves and gastropods from the site. This faunal list was expanded by Ager *et al.* (1973). Hewitt and Hurst (1977) described the section, and analysed size changes and ecology of various molluscs through the middle part of the succession. Aspects of the fauna and sedimentology were discussed in subsequent papers by Hewitt (1980a,b, 1989, 1996) who has undertaken a detailed study of the site; some of his observations are reported here for the first time. A longer lithostratigraphical log was published by Phelps (1985), who tied the section into the ammonite biostratigraphy and found the site invaluable in subdividing the Luridum Subzone into zonules. Callomon and Oates (1993) provided an updated account, and Bessa and Hesselbo (1997) published a gamma-ray log of the section. The most recent account, which reproduces the section by Callomon and Oates (1993), is in the *Fossil Fishes of Great Britain* GCR volume (Dineley and Metcalf, 1999). Other papers have been concerned largely with palaeontological aspects of the site. It has provided material for interpreting the evolution of the liparoceratid ammonites (Callomon, 1963; in Hemingway *et al.,* 1969) and the bivalve *Gryphaea* (Jones and Gould, 1999), for estimating the depth limits in life of several ammonite species (Hewitt, 1996), for investigating echinoid lantern morphology in relation to the origin of irregular echinoids (Smith, 1981), and for providing a control sample for belemnite abundance in Jurassic clays (Hewitt, 1980b). Johnson (1984) figured specimens of the bivalve *Pseudopecten equivalvis* from the locality, and Simms (1989) figured some of the crinoid material. Howarth and Donovan (1964) figured two specimens of *Tragophylloceras carinatum* from here as paratypes of this rare ammonite species. Aspects of the microfauna were described by Malz and Lord (1976) and by Macfadyen (1941).

Description

The most complete section of Blockley Station Quarry is that of Callomon and Oates (1993; reproduced in Dineley and Metcalf, 1999). They recorded just over 20 m of, predominantly, mudstones divided into nine distinct beds (Figure 4.9). The log by Phelps (1985) was divided into 12 lithostratigraphical units *in* a 17 m-thick section. The lower six of his units correspond to a section described by Callomon (in Hallam, 1968a). The description of Hewitt and Hurst (1977) adds lithological detail, but less of the succession was exposed at that time.

The present-day working floor of the brickpit lies on a moderately well-cemented shelly limestone referred to as the 'Crinoid–Belemnite Bed' (Callomon and Oates, 1993), or 'Bed Z' (Dineley and Metcalf, 1999). This bed is richly fossiliferous with several species of bivalve and abundant belemnites, crinoid and comminuted shell and fish debris.

Glauconite grains and ?phosphatic nodules are present, and some of the thick-shelled bivalves are somewhat worn and bio-eroded (R.G. Clements, pers. comm.). Ammonites are relatively common, but poorly preserved. They appear to be referable to *Acanthopleuroceras* (R.G. Clements, pers. comm.), corresponding to Fauna I of Callomon (in Hemingway *et al.,* 1969). Older strata have been exposed in a drainage sump (C.J. Underwood, pers. comm.). Bed Z is underlain by 0.9 m of dark-grey shelly marl, with irregular cemented patches up to 0.2 m across. Below are two 0.1 m-thick nodular shelly limestones, the upper one with abundant *Gryphaea,* separated by 0.15 m of grey shelly clay. Below this, the succession was largely flooded: it comprises grey clay with relatively few shells.

Above Bed Z, Bed 1 of Callomon (In Hallam, 1968a; Callomon and Oates, 1993) comprises 8.5 m of richly fossiliferous grey silty micaceous mudstone with scattered nodules and francolite-cemented *Thalassinoides* burrows. It has yielded species of *Liparoceras* and *Aegoceras,* which Callomon grouped together as his Fauna II. The upper 1.5 m shows an increase in silt content and a marked increase in the abundance of fossil material and pyrite (Hewitt and Hurst, 1977). Bed 2 is the 'Blockley Shell Bed', referred to by Callomon (in Hallam, 1968a) and Hewitt and Hurst (1977) as the 'Pecten Bed'. This is a highly fossiliferous mudstone or series of siderite nodules set in the top of a shell gravel. Small francolite concretions, containing crustacean fragments and encrusted with *Plicatula* and millimetre-scale borings, occur at the base of this bed (R. Hewitt, pers. comm.). Bed 2 is up to 0.5 m in thickness and forms the most important marker band of the succession. It contains *L. fimbriatum* and *T. loscombi* together with liparoceratids of Callomon's Fauna III. Phelps (1985) placed the boundary between his Rotundum and Crassum zonules at the base of Bed 2. The Blockley Shell Bed is separated by 0.3 m of grey mudstone from Bed 4, a second horizon of siderite nodules in a mudstone matrix. This has yielded a distinct assemblage of liparoceratids (Callomon's Fauna IV). Bed 4 is succeeded by 10 m of silty mudstone with scattered nodules and layers of shell debris, divided into two distinct beds by Callomon (in Hallam, 1968a). There is a marked change in the diagenetic mineral content of the sediments, from francolite and pyrite in beds 1 and 2 to siderite in beds 3 to 6 (R. Hewitt, pers. comm.). The exposed succession is capped by an impersistent, buff bioturbated siltstone up to 0.2 m thick overlain by 1–2 m of weathered day. These two units (beds 7 and 8) have been tentatively assigned to the Maculatum Subzone (Callomon and Oates, 1993).

The abundant and diverse fauna at this site is dominated by molluscs. There are at least 44 species of bivalve, 9 species of gastropod, 14 species of ammonite, and scaphopods and belemnites (Callomon in Hallam, 1968a; R. Hewitt, pers. comm.). Most of the liparoceratid species have a restricted vertical range within the succession while *Lytoceras fimbriatum* and *Tragophylloceras loscombi* occur commonly throughout. Hewitt (pers. comm.) noted that the mudstones of Bed 1 are dominated by *Cardinia,* including large numbers of juveniles only a few millimetres across, whereas the shell gravels of Bed 2 support an adult-dominated population of the bivalve *Astarte.* Other common invertebrate macrofossils include brachiopods, crustaceans, crinoids and echinoids. Scaphopods are particularly common in Bed 5. Preservation is often extremely good, with many bivalves and ammonites crushed flat but with their original aragonitic shells preserved intact and unworn. Ammonites and other fossils preserved in nodules typically retain their three-dimensional shape although the septa of ammonites are commonly fragmented. The hollow gas chambers of the ammonites, and some of the unfilled fractures in septaria, are commonly lined with small crystals of pyrite and, more rarely, sphalerite. Crustacean remains in the francolite nodules of Bed 1 preserve parabolic chitin fibre patterns, but these are lacking in the francolite nodules of Bed 2. Although articulated crinoid and ophiuroid material has been found, echinoderm material is more typically disarticulated. Nonetheless, it is commonly unworn and shows exquisite stereom preservation (Smith, 1981; Simms, 1988, 1989). Vertebrate material is scarce but has included partial skeletons of at least three plesiosaurs, one of which is now in Gloucester City Museum. The most recently discovered of these, now in New Walk Museum, Leicester (cat. no. LEICT G1.2002), is the most complete, comprising more than 80% of a 3 m-long skeleton including parts of the skull. It was recoverd from the mudstones of Bed 1, just above the Crinoid–Belemnite Bed.

The microfauna includes foraminifera and abundant ostracods, together with disarticulated ophiuroid and asteroid debris, and the microfossils are also abundant, diverse and very well-preserved. This was one of many GCR sites investigated for foraminifera by Copestake (1989) and was the source of paratype material for *Haplophragmoides lincolnensis* (Copestake, 1986). Microshark and semionotid teeth, denticles and scales are common in the Crinoid–Belemnite Bed (Dineley and Metcalf; 1999), and at least two taxa of fish otoliths have been recovered from the clays of Bed 1 (C.J. Underwood, pers. comm.).

Interpretation

The biostratigraphical significance of the succession exposed at Blockley Station Quarry has been recognized for several decades. Dean *et al.* (1961) referred to the site in their description of the Luridum Subzone, contrasting its thick development there with the highly condensed sequence on the Dorset coast (Figure 4.9). Callomon (in Hemingway *et al.,* 1969) recognized the importance of the liparoceratid faunas in subdividing the succession, identifying four distinct assemblages (Faunas I–IV). Subsequently Phelps (1985) subdivided the Luridum Subzone into what he termed 'zonules'. He assigned Bed 1 at Blockley Station Quarry to his 'Rotundum Zonule' and the remainder of the exposed succession, some 11 m in total at that time, to his 'Crassum Zonule'. However, there are doubts surrounding the identity of the specimens Phelps identified as *Beaniceras crassum* (J.H. Callomon, pers. comm.); they represent a form distinct from *B. rotundum* but are also distinct from S.S. Buckman's holotype of *B. crassum.* The latter almost certainly came from a level lower in the Ibex Zone. Callomon (pers. comm.) has recorded forms close to *Beaniceras luridum* in beds 2, 3 and 4. Evidence from the Napton Hill Quarry GCR site indicates that *Liparoceras naptonense* and *L. kilsbiense,* constituents of Callomon's Fauna IV at Blockley Station Quarry, occur close to the Luridum–Maculatum subzone boundary. Here there is an apparent conflict between the interpretation of Phelps (1985) of the biostratigraphical succession at Blockley Station Quarry and the evidence from ammonite species other than *Beaniceras.*

Nonetheless, it is probable that the entire Luridum Subzone is exposed. The presence of *Acanthopleuroceras in the* Crinoid–Belemnite Bed exposed in the floor of the quarry suggests a correlation of this indurated bed with the '85' Marker Member of Horton and Poole (1977), which is, for convenience, taken to mark the boundary between the Valdani and Luridum subzones (Bessa and Hesselbo, 1997). The presence of Callomon's Fauna IV in Bed 4, and possibly Bed 5, suggests that the section extends up into the lower part of the Davoei Zone, Maculatum Subzone. If so, Blockley Station Quarry offers the best exposure anywhere in Britain of the Luridum Subzone. Despite its exceptional thickness at this site, there is clear evidence that the succession is not complete. The bored and encrusted francolite concretions noted by Hewitt (1980a, 1989) at the base of Bed 2 are similar to the francolite-cemented *Thalassinoides* burrows seen lower in the succession. Both testify to periods of non-deposition and/or erosion. Similarly, the presence of phosphate nodules and bio-eroded shells in the Crinoid–Belemnite Bed (Bed Z) indicate that this too represents a condensed deposit.

The comparison by Phelps (1985) of the Blockley Station Quarry succession with that of the Stowell Park Borehole [SP 084 118], 25 km to the SSW (Figure 4.1), indicates that the former succession is slightly thicker. This probably reflects its position close to the axis of the Mickleton Syncline where 293 m of Lower Lias was proved in the Mickleton Borehole [SP 174 433]. Near llmington, less than 5 km to the east on the East Midlands Shelf, the Lower Lias succession is 61 m thick (Whittaker, 1972b; Williams and Whittaker, 1974). The contrast between the succession at Blockley Station Quarry and that in the Wessex Basin is particularly striking (Figure 4.9). On the Dorset coast the Luridum Subzone is represented by the Belemnite Stone (Bed 121 of Lang *et al.,* 1928), 0.1 m of condensed limestone. Callomon (in Hemingway *et al.,* 1969) correlated Bed 2 of Blockley Station Quarry with the Belemnite Stone, and Bed 1, tentatively, with the 0.02 m-thick Crumbly Bed, Bed 120e of Lang *et al.* (1928). The presence of a hiatus above the Belemnite Stone is significant in that several conspicuous species of ammonite in beds 3 to 5 at Blockley Station Quarry (Callomon's Fauna IV) are absent from the Dorset coast. These thickness differences between Blockley Station Quarry and Dorset demonstrate that subsidence rates in the Severn Basin were greater than in the Wessex Basin during this time interval, with 0.17 m in Dorset equivalent to some 9 m at Bockley Station Quarry (Callomon in Hemingway *et al.,* 1969).

The abundantly fossiliferous mudstones at Blockley Station Quarry are similar to correlative mudstones seen at the base of the succession exposed at the Robin's Wood Hill Quarry GCR site. Both contain a fauna that is significantly more diverse than that of the Davoei and Margaritatus zones, indicating that Luridum Subzone conditions were less inimical to the benthic fauna. Hewitt and Hurst (1977) have published the only palaeoecological description of the Blockley Station Quarry succession. They noted a significantly greater diversity and larger size for molluscs from the Blockley Shell Bed, than from the mudstones of Bed 1, an observation in keeping with that made by Callomon (1963; in Hallam, 1968a) on the liparoceratid ammonites. Fossil material is worn and disarticulated in the lower part of the Blockley Shell Bed, compared with the same species higher in the Blockley Shell Bed and in the mudstones. This indicates that the lower part of the Blockley Shell Bed is a winnowed deposit and this appears to have allowed a greater diversity of benthic taxa to flourish on the shell gravels. This is particularly evident among the bivalves, where the *Cardinia*-dominated, r-selected, population in the mudstones of Bed 1 is replaced by the *Astarte*-dominated, K-selected, populations on the shell gravels in Bed 2. The change in diagenetic minerals, from francolite and pyrite in beds 1 and 2 to siderite in beds 3 to 6, also indicates an increase in sedimentation rate. Palmer (1973) noted a similar increase in mollusc size and diversity in the nodule bands in the sequence at Robin's Wood Hill Quarry, and considered that this indicated that substrate firmness was a major control on benthic diversity during this interval. Malz and Lord (1976) noted that the ostracod assemblage at Blockley Station Quarry was dominated by smooth species, contrasting with that from broadly correlative beds at Robin's Wood Hill Quarry where they found a much higher incidence of ornamented and heavily calcified ostracods. They considered this as evidence for deeper and quieter water conditions at Blockley Station Quarry, perhaps lending support for the greater subsidence rate deduced for this area. Hewitt (1996) analysed septal strength in several common ammonite species at Blockley Station Quarry, from which he was able to calculate the maximum depth limit in life. Since ammonites are considered to have been nektobenthic, this gives a minimum water depth in which the various units were deposited. Hewitt (1996) obtained figures of 94 m for *Liparoceras cheltiense* in concretions from Bed 1, 45 m for *Liparoceras elegans* in Bed 2 and 60 m for *Lytoceras fimbriatum* from Bed 4.

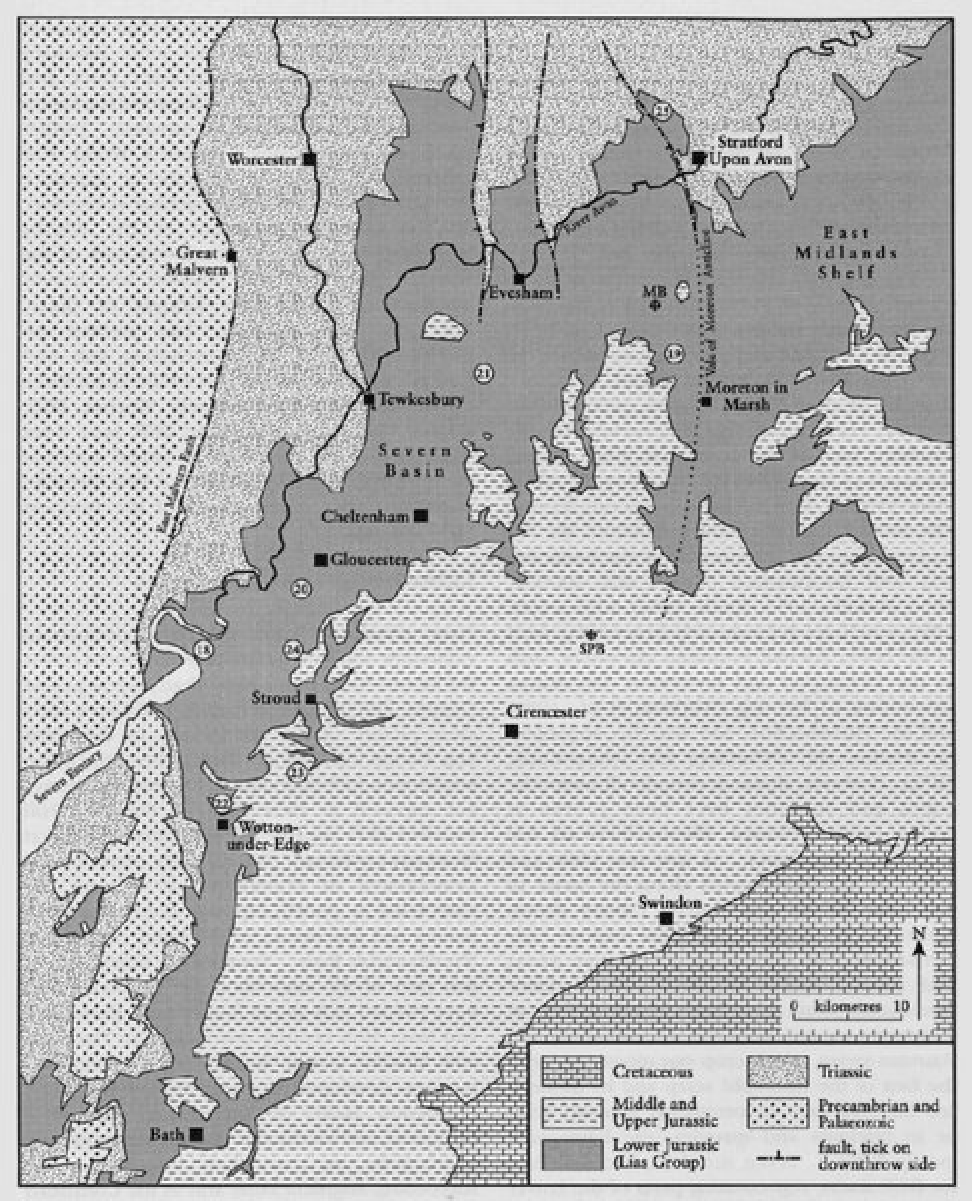
The abundance and excellent preservation of many elements of the fauna at Blockley Station Quarry has attracted palaeontological research. The expanded succession here was crucial to Callomon's (1963) research on the ammonite family Liparoceratidae. In this he was able to demonstrate that the evolutionary sequences proposed by Trueman (1918) and by Spath (1938), from capricorn *Aegoceras* to sphaerocone *Liparoceras* and vice-versa, were untenable. Callomon (1963) proposed that these morphotypes, which occur together at Blockley Station Quarry, represent sexual dimorphs. Subsequently, Hewitt (1989) concluded, from differences in the ontogeny of the sutures in the two morphological groups, that they represented distinct evolutionary lineages. This interpretation was supported by Phelps (1985). However, unless repeated iterative evolution is invoked, the close parallelism in the evolution of both morphological groups supports Callomon's original proposal for sexual dimorphism in the Liparoceratidae.

Only a small proportion of the remaining fauna has been described. Simms (1989) covered the crinoids, and the lantern of an echinoid, *Eodiadema minuta* was described by Smith (1981). Johnson (1984) figured examples of the abundant and exceptionally well-preserved pectinids. Differential wear on the upper and lower valves of specimens of *Pseudopecten equivalvis* from this site suggest that these were among the earliest pectinids to adopt a swimming habit (A.LA. Johnson, pers. comm). Harper *et al.* (1998) figured examples of predatory borings in the bivalves *Astarte gueuxii* and *Plicatula spinosa.* The most recently discovered plesiosaur (LEICT G1.2002), yet to be formally described (Mark Evans, pers. comm.) is of considerable importance since no valid plesiosaur taxa are known between Upper Sinemurian and Toarcian times, a key time for the evolution of this group.

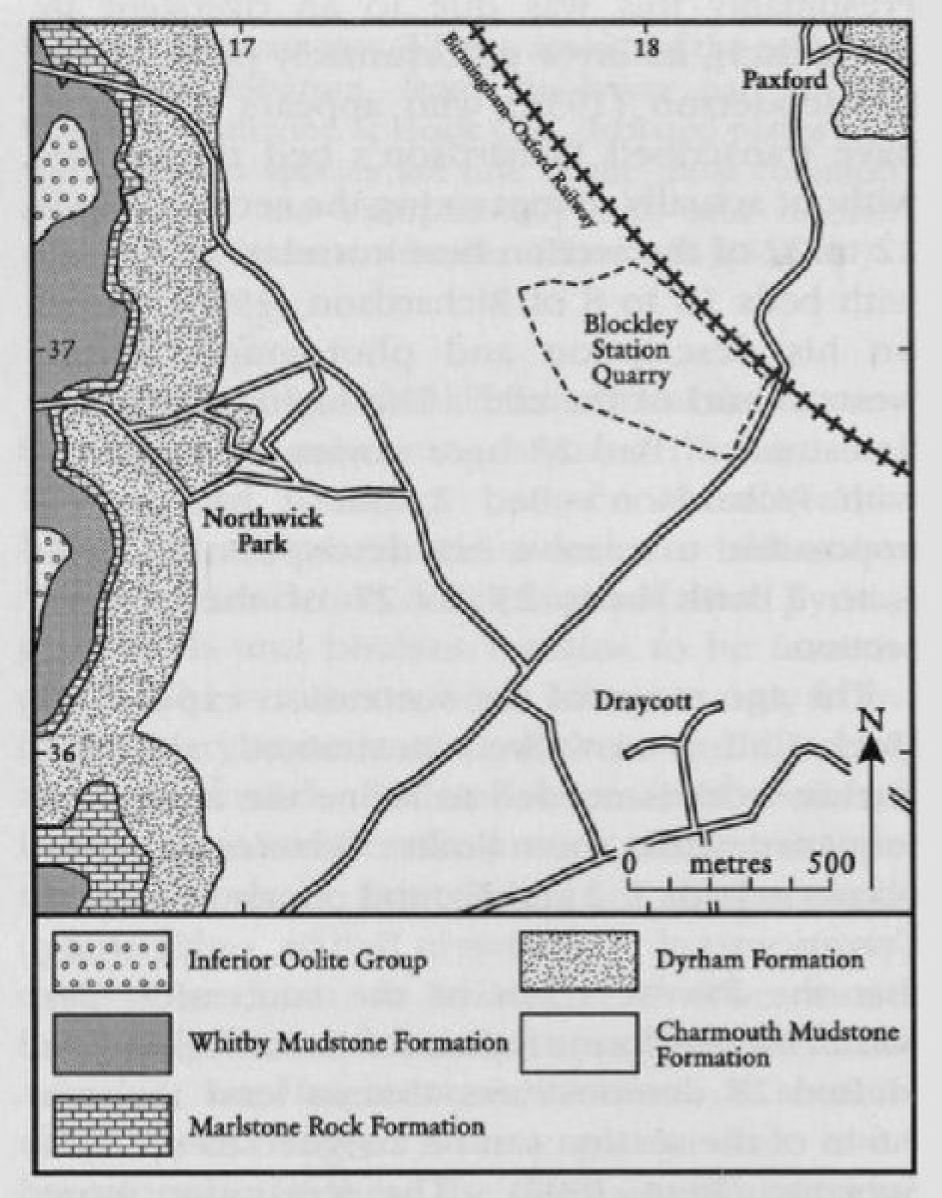
Conclusions

Blockley Station Quarry is one of the few inland sites in Britain to expose a section through the Charmouth Mudstone Formation of the middle part of the Lower Pliensbachian Stage, and has yielded data for comparison with the well-documented coastal sections in Dorset, Yorkshire and the Hebrides. It provides one of the thickest and most fossiliferous developments of the Luridum Subzone of the Ibex Zone and as such will be of crucial importance for any future refinement of the ammonite biostratigraphy of this interval. It has yielded an abundant and diverse fauna, elements of which have been figured and described. In particular, ammonites from this site have been central to the debate on sexual dimorphism in the family Liparoceratidae.

References

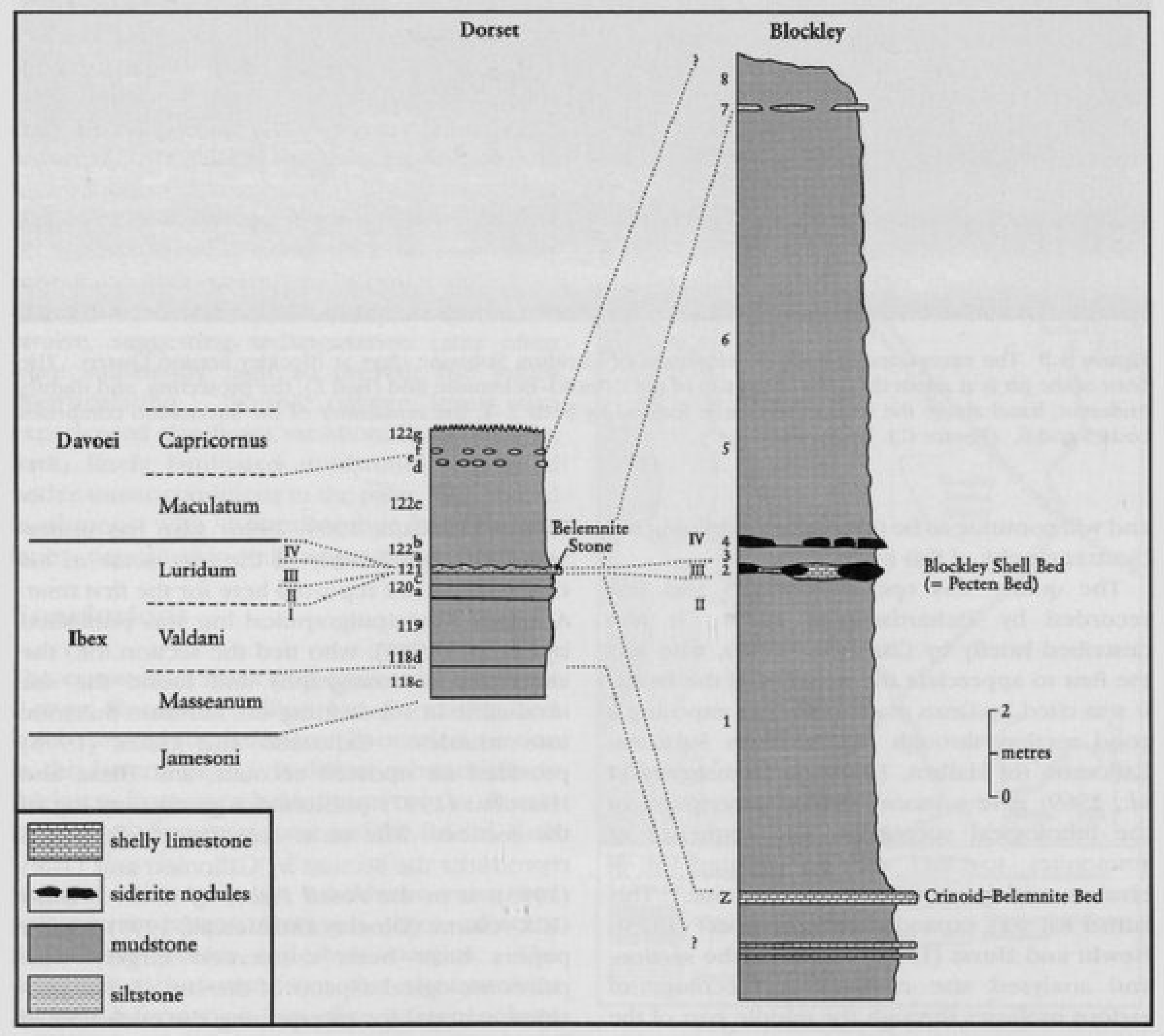


(Figure 4.1) Generalized geology of the Severn Basin and western edge of the East Midlands Shelf. Only the main basin-bounding faults are indicated. Numbers correspond to the locations of the GCR sites: 18 — Hock Cliff; 19 — Blockley Station Quarry; 20 — Robin's Wood Hill Quarry; 21 — Alderton Hill Quarry; 22 — Wotton Hill; 23 — Coaley Wood; 24 — Haresfield Hill; 25 — Newnham (Wilmcote) Quarry (Chapter 5); MB — Mickleton Borehole; SPB — Stowell Park Borehole.



(Figure 4.7) Geology and location map for the Blockley Station Quarry GCR site.

(Figure 4.8) The exceptionally thick development of Luridum Subzone clays at Blockley Station Quarry. The floor of the pit is at about the level of the top of the Crinoid-Belemnite Bed (Bed Z); the projecting, and slightly undercut, band above the second terrace is formed by beds 2–4; the remainder of the succession comprises beds 5 and 6. (Photo: C.J. Underwood.)



(Figure 4.9) Sketch section of the succession at Blockley Station Quarry and correlation with that on the Dorset coast. Roman numerals refer to ammonite faunas described by Callomon and discussed in the text. Based on Callomon (in Hemingway et al., 1969) and unpublished observations by C.J. Underwood.